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ROADMAP TO DECARBONISATION

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Hamworthy

The current landscape

Net Zero Strategy

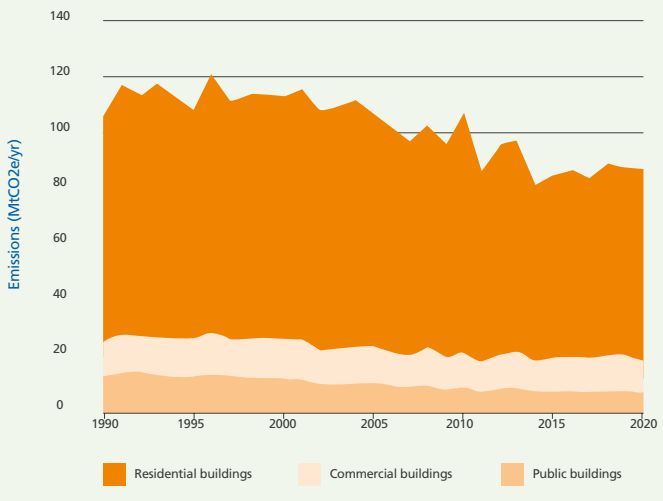
Over recent years, the UK Government has been prioritising their proposed net zero strategies in order to get the country back on track to meet the global goal of reaching net zero by 2050. Net zero refers to the state in which the greenhouse gases (GHGs) being emitted into the atmosphere are balanced by their removal from the atmosphere.[1] Scientific consensus is that the world must reach net zero by 2050 in order to prevent the worst effects of climate change.[2] This is in order to limit the global temperature increase in this century to 1.5°C, which was a leading factor in the historic Paris Agreement made by world leaders in December 2015.[4]

In the UK, there have already been some devastating effects of climate change. Perhaps most visible are flooding events – which have become more frequent,[4] and temperature rises – 2022 was confirmed as being the UK's hottest year on record and the first time the average annual temperature has been above 10 degrees Celsius.[5] The Met Office have said that a UK mean temperature of this number would be expected once in 500 years in a natural climate untampered by GHG emissions but is now likely to occur every three to four years.[6]

In the UK, the buildings sector is the second largest emitter of GHGs – after surface transport – and most of these emissions are a result of heating and hot water demand in homes being fulfilled by natural gas.[8]

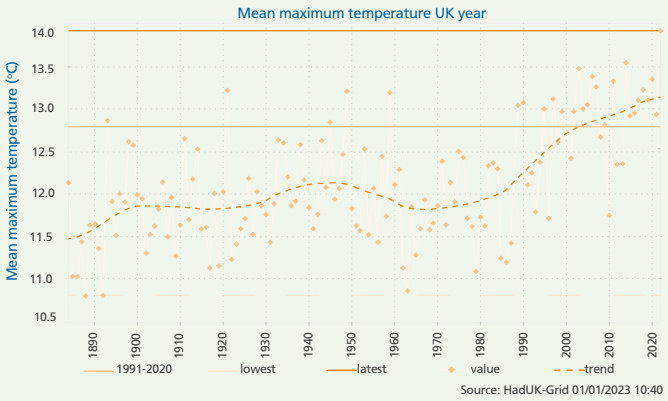
In fact almost 80% of homes in the UK are heated by natural gas.[9] Plus, UK homes, which tend to be older buildings and not as insulated and efficient in retaining heat, use more energy than their European counterparts, meaning that they have a low energy efficiency. In total, the heating of homes and workspaces makes up almost a third of UK carbon emissions.[10] However, cutting emissions is not so simple as telling the population to stop heating their homes.

Direct emissions from buildings



Source: BEIS (2002) Final UK greenhouse gas emissions national statistics: 1990 to 2020.

UK – Mean daily maximum temp[7]



Source: HadUK-Grid 01/01/2023 10:40

[1] 'What is Net Zero?', Net Zero Climate

[2] Ibid.

[3] 'The Paris Agreement', United Nations

[4] 'Climate change means more frequent flooding, warns Environment Agency', GOV.UK

[5] '2022 was officially the U.K.'s hottest year on record – and human-caused climate change made it 160 times more likely', CBS News

[6] 'UK weather: 2022 was warmest year ever, Met Office confirms', BBC News

[7] 'UK temperature, rainfall and sunshine time series', Met Office

[8] 'Independent Assessment: The UK's heat and buildings strategy', Climate Change Committee

[9] 'UK: Heating methods survey, 2022', Statista

[10] 'Net Zero Strategy: Build Back Greener', HM Government

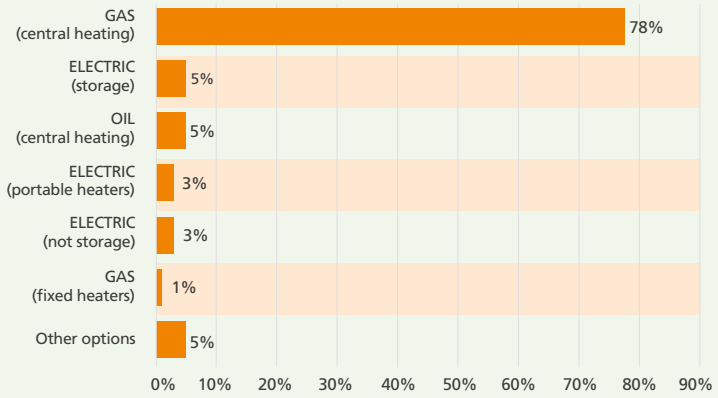
While climate change is leading to warmer on average winters, temperatures still drop to around or below zero degrees and prolonged exposure to low temperatures pose serious risks to human health. The Met Office warns that cold thickens blood, which increases blood pressure, and breathing in cold air can lead to increased risk of chest infections.[11] A 2018 study found that the average temperature of a home in the UK was 17.7ºC; an issue when both Met Office and NHS guidelines recommend homes should be at least 18oC, especially for vulnerable people (those 65+ and children under the age of 5).[12] [13]

In the 2019/2020 winter there were 29,289 excess winter deaths in England and Wales (excluding COVID-19).[14]

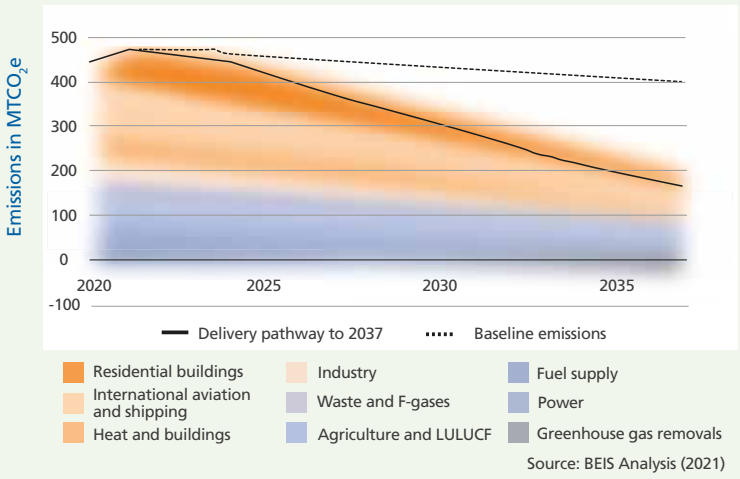
So, although heating is key to the health and safety of the population, it is clear that there needs to be a more sustainable way of providing heat in order to avoid the continued contribution to emissions.

While there has been a steady downward trend of GHG emissions from buildings in the UK,15 action needs to happen on a much larger scale in order to reach a level where a state of net zero will be achievable.

What is the main way you heat your property during the winter?



Indicative delivery pathway to 2037 by sector[16]



Source: BEIS Analysis (2021)

[11] 'Keeping your home warm this winter', Met Office

[12] Ibid.

[13] 'How to stay well in winter', NHS

[14] 'Excess winter deaths in England and Wales 2020', Statista

[15] 'Final UK greenhouse gas emissions national statistics: 1990 – 2022', GOV.UK / 'Independent Assessment: The UK's heat and buildings strategy', Climate Change Committee

[16] 'Net Zero Strategy: Build Back Greener', HM Government

[17] 'BEIS annual report and accounts, 2021 – 2022', GOV.UK

The current landscape

Net Zero Strategy

The Government is aiming to reach this goal through their net zero strategy. This strategy aims to reduce emissions across the economy, including by delivering a decarbonised power system by 2035, halving emissions from oil and gas, delivering 5GW of hydrogen production capacity by 2030 and their commitment to end the sale of new petrol and diesel cars by 2030.[18] A key part of this decarbonisation plan, with regard to buildings and heating, is the replacement of traditional gas boilers with heat pumps.

The Government is investing in a £60 million Heat Pump Ready programme that will fund heat pump technologies, to help support their target of 600,000 installations a year by 2028.[19]

The Heat Pump Ready Programme was created with the aim of supporting the development of innovative solutions across the sector – it is divided into three streams:

Stream 1

Focused on solutions for heat pump deployment, supporting the development and trial of such solutions, with the overall aim of optimising the deployment of domestic heat pumps at the high rate required for the Government's aims.

Stream 2

Focuses on the development of tools, technology and processes to overcome specific barriers to the deployment of domestic heat pumps.

Stream 3

Which is currently running its second phase, focuses on support and learning, providing knowledge transfer and shared learning across the Programme – it ultimately unites Stream 1 and Stream 2 projects where relevant, establishing working groups for collaboration on shared elements of heat pump deployment.[20]

For consumers, the Government is offering the Boiler Upgrade Scheme, which grants households up to £5,000 to help switch from a gas boiler to a heat pump. However, so far grant take-up is so low that the Lords Climate Change Committee said the national target for green heating is "very unlikely to be met".[21] Much of this low uptake can be accredited to low consumer awareness of the scheme and of heat pumps in general. As a result, the Government is due to embark on a marketing campaign to raise awareness.

[18] 'Net Zero Strategy: Build Back Greener', HM Government

[19] 'Net Zero Strategy: Build Back Greener', HM Government

[20] 'Heat pump ready programme: Successful projects', GOV.UK

[21] 'Heat pumps: Lords slam 'failing' green heating scheme', BBC News

The current landscape

Public Sector Decarbonisation Scheme

There is also the **Public Sector Decarbonisation Scheme,** an investment of £1.425 billion which is intended to reduce emissions from public sector buildings by 75% by 2037. This scheme is divided into three phases, two of which are complete, with Phase 3 currently running.[22]

Phase 1

This phase provided £1 billion in grants over the financial years 2020-2021 and 2021-2022, aiming to support up to 30,000 jobs in the low carbon and energy efficiency sectors, as well as reduce carbon emissions from the public sector. Heat pumps were the second-most installed technology in Phase 1 projects, behind lighting.

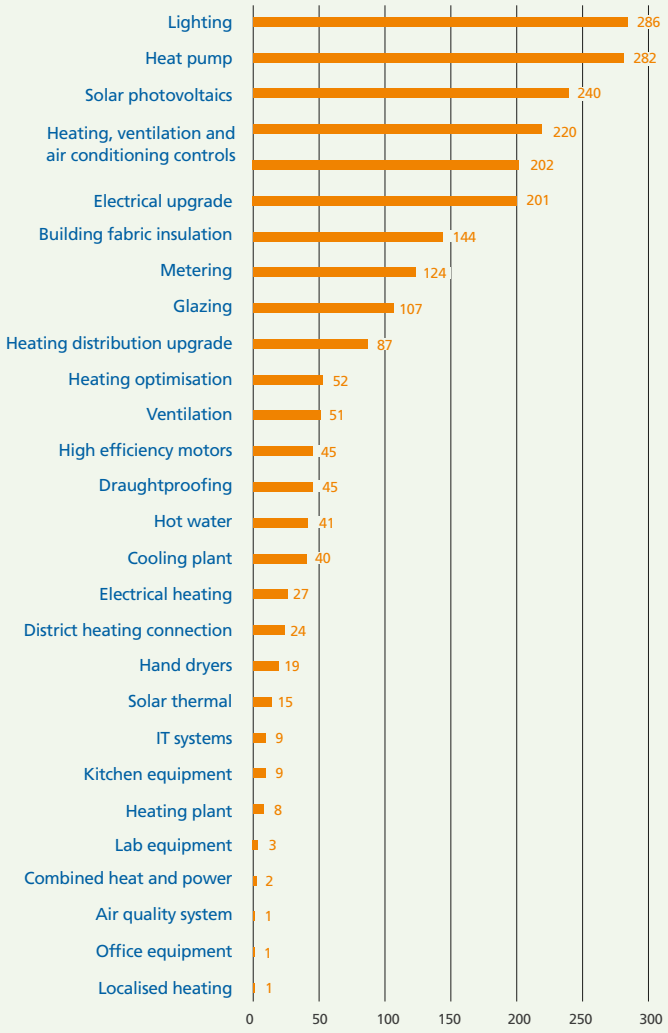
Phase 2

This phase provided £75 million of grant funding for the financial year 2021-2022, with a stronger focus on heat decarbonisation than Phase 1 to fulfil greater carbon emission reductions.[23]

Phase 3

This is providing £1.425 billion of grant funding over the financial years 2022-2023 to 2024-2025.[24]

Number of projects installing one or more of each technology[25]



[22] 'Public Sector Decarbonisation Scheme', GOV.UK

[23] 'Public Sector Decarbonisation Scheme: Phase 1 summary report', GOV.UK

[24] 'Public Sector Decarbonisation Scheme', GOV.UK

[25] Ibid

The current landscape

Case Studies

Science and Industry Museum, Manchester[26]

The Museum was awarded £4,288,727 to improve building fabric and install new mechanical and electrical systems to the Museums Grade II listed Power Hall. It will also fund the infrastructure for a site-wide water source heat pump, ground source heat pumps and air source heat pumps across the site.

These measures will contribute to the decarbonisation of the Museum, supporting Greater Manchester's goal to become carbon neutral by 2038.

[26] 'Public Sector Decarbonisation Scheme: Phase 1 summary report', GOV.UK

Gateshead NHS Foundation Trust[28]

The Trust was awarded £1,527,865 to install air source heat pumps in buildings across its property portfolio. The transport, IT and estates departments will also receive heat pumps. The electricity for these heat pumps will be supported by solar panels being installed on roofs. Furthermore, the building management system will also receive an upgrade to improve energy efficiency.

Wolfson College, University of Oxford

The College was awarded £4,999,999 to install heat decarbonisation and energy efficiency measures in the main building of the college. Air source heat pumps will be installed, in order to remove gas as a source of heat energy for the college. The building fabrics will also be updated, with insulation added to interior walls and double-glazing installed.

The projects under this scheme serve to truly highlight the vast opportunities within the low carbon and energy efficiency sectors. But it also serves to indicate how key support from the Government is when it comes to these early stages of the move from traditional energy systems to innovative and low or zero carbon technologies.

On top of this decarbonisation scheme, there is also the Public Sector Low Carbon Skills Fund, which provided grants for public sector organisations to engage the expert advice and skills they need to put a heat decarbonisation plan in place. This fund also has three phases, the last of which ceased accepting applications on 31st March 2023.[27]

[27] 'Public Sector Low Carbon Skills Fund', GOV.UK

[28] 'Phase 2 Public Sector Decarbonisation Scheme: Project summaries notice', GOV.UK

The current landscape

Private Sector

Currently there is no equivalent funding support for the private sector, which is stalling the uptake of heat pumps, particularly when the technology needs to be retrofitted into existing systems. The overall capital required to make the switch to a heat pump is still often a considerable factor that commercial clients must consider against the less expensive option of a boiler.

The policies and programmes outlined in the heating section of the strategy all emphasise just how important the decarbonisation of heating is to the aim of reaching net zero.

UK homeowners, social housing associations and local authorities are collectively seeking robust solutions to minimise their carbon emissions and reduce the environmental impact of residential energy use. As a result, the market is currently at a tipping point, with the energy sources of electric versus gas driving competition.

This paper largely calls upon data and examples relating to domestic heat pumps. As domestic heating contributes a larger amount of CO2 emissions than commercial heating, it is a clear starting point for the Government to focus their plans surrounding the decarbonisation of heating and thus much of the research and analysis available centres around domestic rather than commercial. However, it is important to take them into consideration from a commercial point of view – particularly when it comes to pain points that consumers and commercial planners could potentially share. There is also the fact that legislation surrounding efficiency measures often begin with domestic before evolving to cover commercial. For example, the Future Homes Standard, which outlined changes to domestic building regulations for a variety of issues, including energy efficiency, was announced first, before non-domestic buildings were considered in the Future Buildings Standard. So, it is evident that an awareness and investment now will prepare you for the future expansion of focus.

Building regulations, increasing consumer awareness and future energy policy are key drivers in the uptake of renewable technologies such as heat pumps.

The challenges of implementing a roadmap to decarbonisation and the opportunities with making the transition

How heat pumps work

Heat pumps are classed as reverse Carnot heat engines[29] – a system that is undergoing a Carnot cycle,[30] but in reverse. The engine absorbs heat from a cold thermal reservoir and transfers it to a warmer thermal reservoir.[31]

The reverse Carnot cycle consists of four reversible processes:

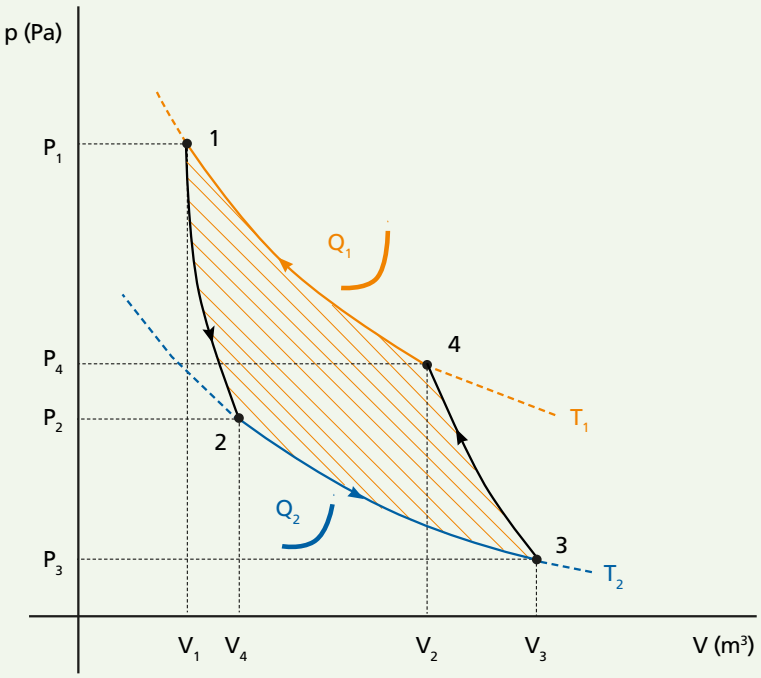
1. **Adiabatic expansion** – the ideal gas expands adiabatically (meaning heat does not enter or leave the system), cooling down to the temperature of the cold thermal reservoir.

2. **Isothermal expansion** – the ideal gas expands at a constant temperature in contact with the cold thermal reservoir, absorbing heat energy.

3. **Adiabatic compression** – the ideal gas is then compressed – also adiabatically – and its temperature rises to the temperature of the hot thermal reservoir.

4. **Isothermal compression** – the ideal gas discharges heat energy to the hot thermal reservoir.

The reverse Carnot cycle is shown on a PV diagram in the following figure:[32]



29 'Carnot heat pump (or Carnot refrigerator)', YouPhysics

30 'What is Carnot cycle – Carnot heat engine – Definition', Thermal Engineering

31 'Carnot heat pump (or Carnot refrigerator)', YouPhysics

32 Ibid.

The challenges

How it works

That is the physics behind each stage, but when it comes to heat pumps specifically, the technical aspect of each stage is as follows:

1 Capture

The fan passes ambient air over extremely cold liquid refrigerant. The refrigerant captures the heat from the ambient air and becomes a warm vapour.

2 Exchange

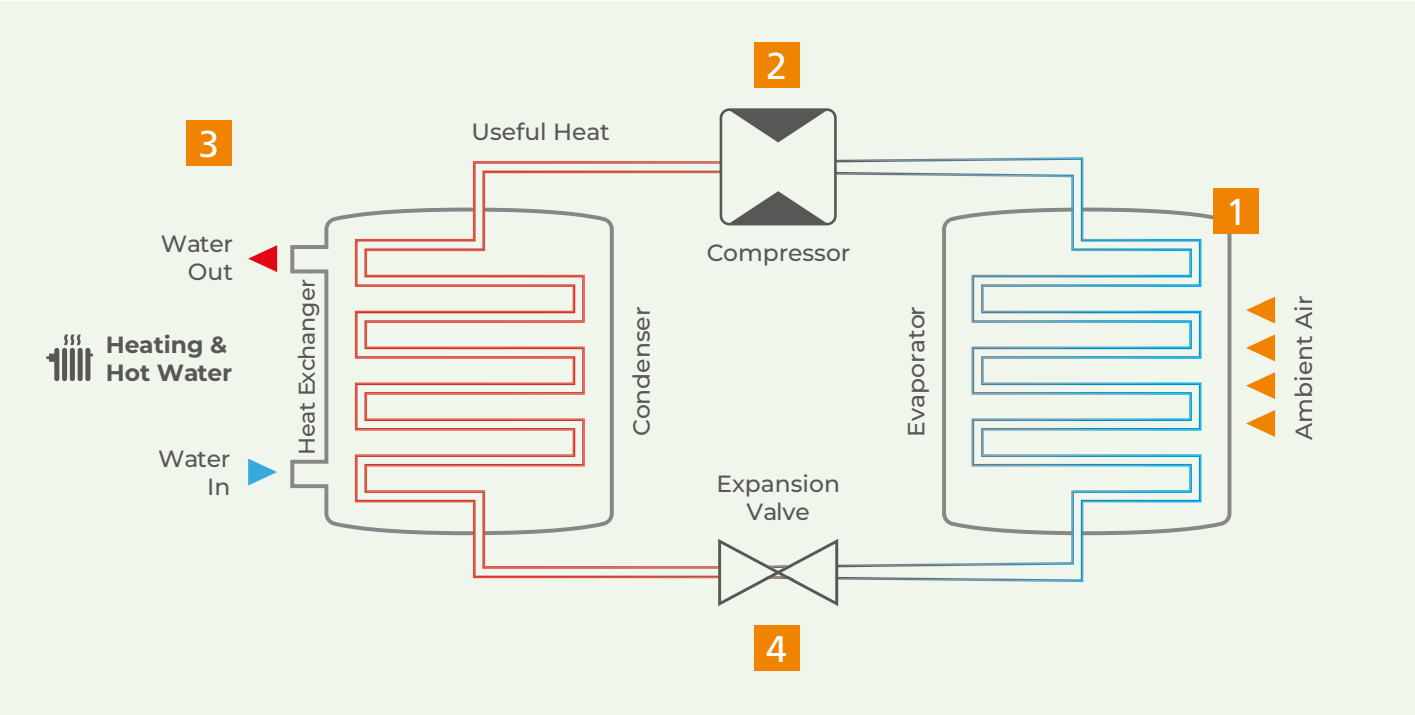
The heat in the hot refrigerant is then transferred to the heating and hot water through a heat exchange.

3 Compress

The warm refrigerant vapour passes through a compressor which produces hot refrigerant and usable heat.

4 Expand

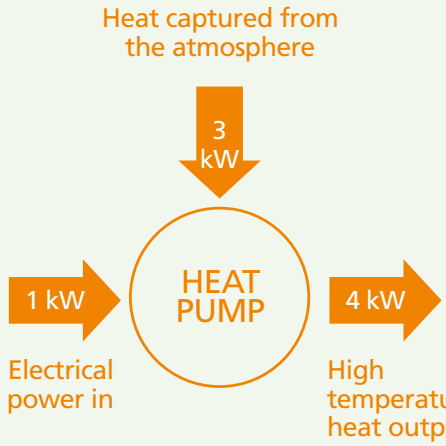
As the heat is transferred the refrigerant passes through an expansion valve which reduces its temperature, making it really cold again and enabling it to capture heat from the ambient air, continuing the cycle.



The challenges

The Coefficient of Performance (COP)

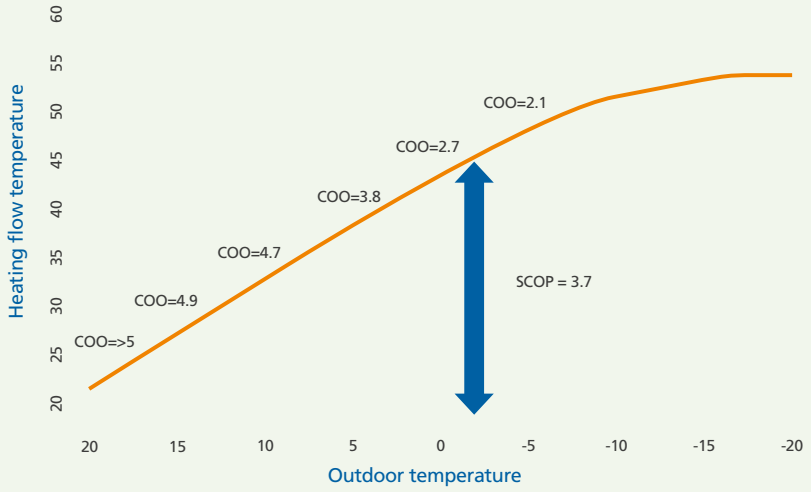
The COP is the ratio of how much useful heat a heat pump will produce if we give it a certain energy input.[33]

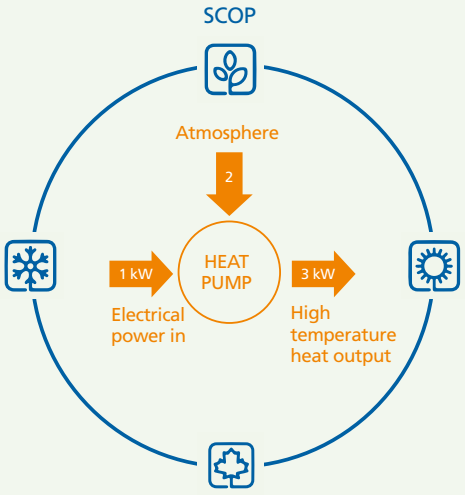


Seasonal Coefficient of Performance (SCOP)

The SCOP defines a heat pump's performance throughout use. To calculate it, the sum of heat energy produced over the season is taken in kilowatt per hour (kWh) and divided by the sum of energy consumed over the same period, also taken in kWh.[34]

Example of air source heat pump seasonal operating range





The seasonal coefficient of performance (SCOP) is the average COP carried over the annual heating season (the full year).[35]

33 'Understanding COP: Coefficient of Performance of heat pumps', LearnMetrics

34 'What is SCOP (Seasonal Coefficient of Performance)', Cooling Heating Services

35 'Heat pumps role in the net zero goal', Hamworthy Heating

The challenges

Why heat pumps for net zero?

Presented in 2021, the Government's net zero strategy outlined a ten-point plan, of which heating and buildings was a major focus. As delineated in this paper, the buildings sector is the second largest emitter of GHGs in the UK, hence the Government's focus on it. They are hoping to achieve the necessary decarbonisation of heating through the increased installation of heat pumps – both in new build properties and commercial sites and retrofitting in older properties to replace gas boilers. Heat pumps are significantly – up to a third – more efficient than gas boilers, with potential for even further efficiency as the technology develops, meaning they require less energy to run. Of course, this level of efficiency does rely on the key success factors of system design and the overall thermal efficiency of the building. A heat pump system that is not correctly sized, or a building without effective insulation, will require more energy to keep at the desired temperature, meaning the heat pump is then not operating at maximum efficiency.

Their energy efficiency means that they are able to help reduce the load on power stations, and they assist with electricity grid management. Because heat pumps produce more heat than the electricity they consume, and they therefore reduce the load on the grid. And furthermore, heat pumps with smart controls actually learn the occupant's preferences and building heat physics, which makes it possible to reduce the peaks of grid strain whilst power stations are currently still producing both gas and electricity.

It is key when considering the switch to heat pumps, that the existing system and building fabrics are assessed beforehand – this may include the addition or replacement of radiators to the building's current system – and that the insulation and glazing are as efficient as the building regulations allow.

On top of this, while gas has historically been very cheap when compared to electricity prices, the price of gas has risen substantially over the past year, with the October 2022 energy price cap increase meaning the average household will now pay £3,549 annually on energy bills.[36] As a result, renewable energy sources such as heat pumps are becoming more and more attractive to home and business owners, even with the larger upfront installation fee.

The differential in the average price cap unit between electricity and gas has continued to close over the past two years.

While in the October 2021 – March 2022 period, the average price cap unit rate of electricity was nearly 1.4x that of gas, by April 2023 this had shrunk to 1.1x. This trend is forecast to continue with the price of gas eventually expected to overtake electricity.

Analysis done in 2022 shows that efficient heat pumps can save households up to 27% on their heating bills when compared to a gas boiler[37]– which, if we take the above annual bill of £3,549, would be a saving of up to over £650 per year. With the Government's prioritisation of heat pumps, they are expecting that they will become as cheap to buy and run as a gas boiler by the end of this decade.[38]

Ultimately, not only are heat pumps clearly an efficient decarbonisation solution, but they're also steadily becoming more cost-effective, and the Government expects that the cost of installation will continue to fall as the market scales up. In fact, we are already seeing evidence of what some are calling 'price wars' for the installation of heat pumps, with some installers saying they will price match any offer by a rival company for accredited installations.[41] All of this contributes to heat pumps' place within the Government's decarbonisation plan.

Cost per kWh [39] [40]				
	1 October 2021 – 31 March 2022	1 April – 30 September 2022	1 October 2022 – 1 April 2023	
Electricity	£0.21 per kWh	£0.28 per kWh	£0.34 per kWh	Prices representative of average price cap unit rates for typical usage for the period
Gas	£0.04 per kWh	£0.07 per kWh	£0.10 per kWh	
LPG	£0.11 per kWh	£0.09 per kWh	£0.09 per kWh	Prices representative of average actual cost

[36] 'Boilers vs heat pumps comparison (2023)', GreenMatch

[37] 'Analysis: Running costs of heat pumps versus gas boilers', Regulatory Assistance Project

[38] 'Net Zero Strategy: Build Back Greener', HM Government

[39] 'Average cost of electricity per kWh in the UK, 2023', NimbleFins

[40] 'Energy cost comparison', Nottingham Energy Partnership

[41] 'British gas kicks off price war for heat pumps', The Telegraph

The challenges

Making the transition – the opportunity

With the Government declaring heat pumps their preferred route to decarbonisation of heat, it is clear that the market for heat pumps will only grow. For example, the Future Buildings Standard proposes that from 2025, new non-domestic buildings will be highly efficient, using low carbon heating and the best possible fabric standards in order to be considered zero carbon ready.[42]

Heat pumps are an established technology, already being installed at a high rate – with the demand for heat pumps surging by 28% in 2021[43] – making it evident that these are a renewable technology which is here to stay.

However, this was still only to a total of about 60,000,[44] far below what the Government is aiming for. The rate of installation needs to continue to grow, with which hopefully the market will scale, and as the market and number of skilled designers and engineers scales up, heat pump technology will only get more innovative and effective. For the rate of installation and innovation within the industry to grow, however, the skills gap that currently exists must be closed.

While the compressor and pumps in the heat pump system require electricity, they use less than other systems as the quantity of heat moved from outside to inside is larger than the amount of electricity they use. In commercial buildings, for example, heat pump use can reduce CO_2 emissions by up to 70%.[45] With the volatile energy prices – where businesses' energy bills are reaching unsustainable levels for almost half of those surveyed[46] – these low carbon options offer cost-cutting opportunities and a way to help reduce reliance on fossil fuels.

Heat pumps are also an increasingly popular option due to their flexibility. As with other low carbon technology like electric cars where consumers benefit from a reduced tariff to charge their cars at home, many energy companies are now offering smart or flexible tariffs aimed at those who use heat pumps.[47] This helps make running costs more affordable by providing flexible unit rates at different times of day, offering cheaper rates when the national grid is experiencing lower demand.[48] Additionally, demand-side response (lower prices for customers who use more energy at times when energy supply exceeds demand – such as wind farms producing extra electricity if the wind blows strongly at night when demand is low) offers companies the opportunity to delay their demand for electricity when it's expensive.[49]

[42] 'The Future Buildings Standard: Summary of responses and government response', GOV.UK

[43] 'Demand for heat pumps has surged by 28% in 2021, research shows', Homebuilding

[44] 'Octopus Energy braced to install thousands of heat pumps in 2022', Heating and Ventilation News

[45] 'How Ideal heat pump technology changes the future of heating', Ideal Commercial Boilers

[46] Ibid.

[47] 'Electricity tariffs: A guide for electric car drivers', EDF Energy

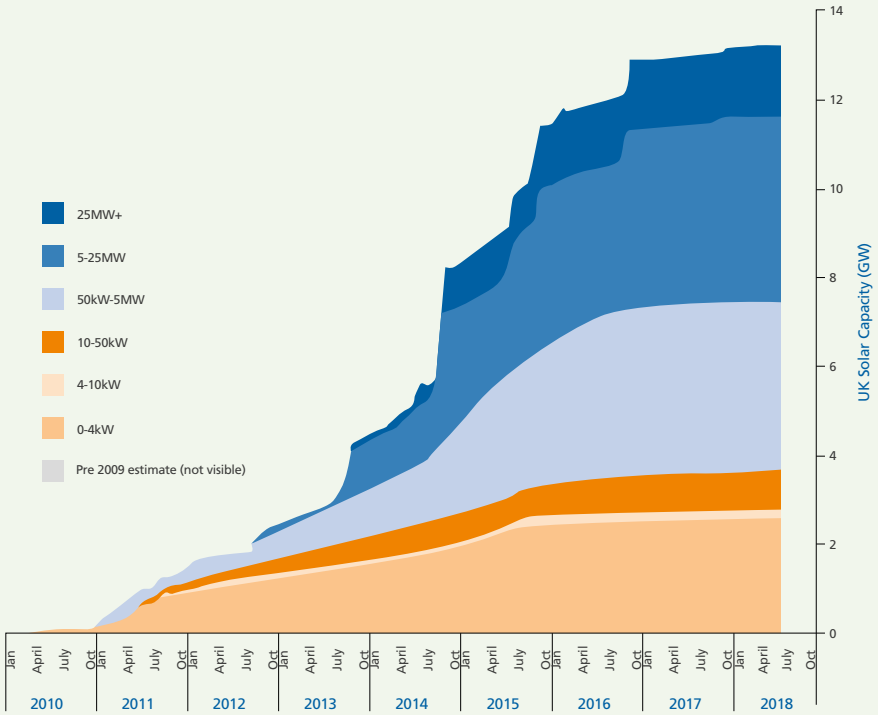
[48] 'Heat pump tariff', Energy Performance Validation Scheme

Heat pumps are also easily integrated with other renewable technologies, – such as solar photovoltaic (PV) panels and battery / thermal storage.

Solar PV panels can power air source heat pumps to generate heating and hot water needs while being kind to the environment by reducing the need for electricity. Solar PV panels are becoming increasingly more common in the UK and could provide an excellent renewable alternative to power heat pumps. Adding in battery storage to the equation means excess energy generated by the panels can be stored so that heat pumps can still operate even when the sun is not shining.[51] Of course, a totally independent renewable system for domestic use would require a huge number of panels, let alone one required for commercial use.

Plus, the batteries needed for this storage are still a costly investment,[52] particularly at the scale that would be needed for commercial or industrial properties. Solar PV panels also come with their own set of challenges. One of the most notable being the current limitations of the efficiency of solar PV cells. For commercial use, solar cells only convert 16% of sunlight energy for further use, with the rest being wasted.[53] Additionally, solar PV panels are currently still more expensive than alternative systems, with the high initial capital that is needed, plus the maintenance cost of the system, meaning it can take up to 15 years to break even with the initial investment.[54] So, currently, there is still a need for a connection to the grid, however as the technology develops there could be further opportunity for renewable integration and less and less reliance on the grid.

UK Solar Deployment – By Capacity (UK Department for BEIS,2018)[50]



[49] 'Demand side response', ICAX

[50] 'Solar energy in the UK – Challenges and opportunities', BJSS

[51] 'How can battery storage and solar work alongside heat pumps?', AceOn Group

[52] 'Challenges of solar energy storage', MK Battery

[53] 'Challenges of solar energy', Solar-Panels

[54] Ibid.

The challenges

Making the transition – the opportunity

This lowering of reliance on the grid is also a focus of the Government on their path to net zero, with the Green Heat Network Fund (which began in Spring 2022) offering funding to public, private and third sectors developing heating and cooling networks in England in order to support the rolling out of low-carbon technologies.[55]

Not only does heat pump technology offer great opportunity for heating companies as the world moves away from a reliance on gas boilers, but it also provides numerous training opportunities. The still relatively new and innovative heat pump system requires the training and upskilling of the current workforce, creating a huge area for potential new jobs and roles. However, this potential will only be truly fulfilled if the Government invests in long-term commitments to upskill the industry. This will likely be one of the biggest challenges. The Government is investing in projects, such as the recent Home Decarbonisation Skills Training competition, which concluded on 31st March 2023. This was a round of funding (£9.2 million) to offer free and heavily subsidised training opportunities for installers of clean heating and energy efficiency installers. It delivered 8,900 courses at accredited centres across England, funding those who were already in the heating and plumbing sector and looking to retrain or develop their skills, as well as those looking to enter and work in energy efficiency, building retrofit and low carbon heating sectors. Organisations that are successful in this latest funding round will provide installer training that leads to a recognised NVQ qualification or equivalent and Continuing Professional Development-style short courses.[56] This is certainly a step in the right direction, but it is one that must continue if the Government wants to achieve their goal of 600,000 installations a year in only 5 years' time.

[55] 'Green Heat Network Fund: Proposals for the scheme design', GOV.UK

[56] 'Training for thousands to take advantage of green job opportunities', GOV.UK

The challenges

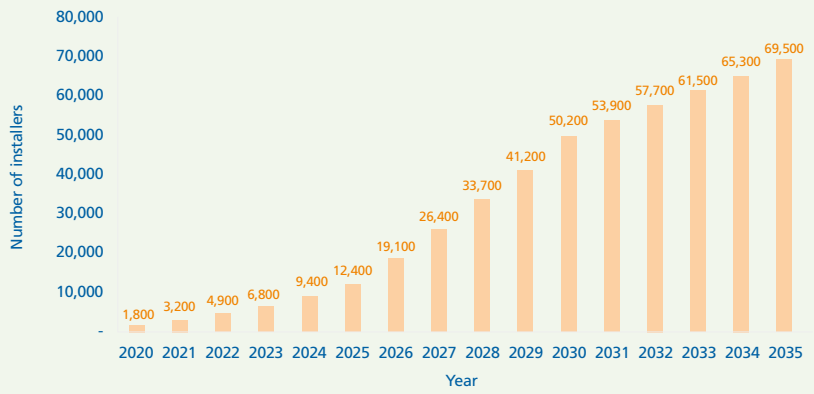
Installers

As of July 2022, the number of qualified heat pump engineers was estimated to be around 3,000, but according to Nesta's modelling the UK will need at least 27,000 qualified engineers by 2028 to meet the Government's installation targets.[57] This means training of 5,000-7,000 installers per year between 2025 and 2035.[58] These low numbers of installers has supposedly contributed to the challenges facing the Government's Boiler Upgrade Scheme, its problems being reminiscent of the previous Green Homes Grant in 2021 which was scrapped after less than a year due to lack of installers for energy efficient household measures.[59]

With all this in mind, it is clear that changes should be made and encouraged on a local governmental level, as well as national.

One such example is Bristol City Council's recent bid for Government funding for a project focused on training and building up a local supply chain, with the aim of eventually installing heat pumps across the city.[60]

Potential total heat pump installers needed[61]



With the Government's focus on heat pumps, and the grants they are providing to support their widespread installation, the adoption rate of this technology will only increase. And with that higher rate of adoption, we can expect a high rate of innovation as focus turns to heat pump developments in favour of older, fossil fuel-reliant technology. For example, there are engineers in Scotland who have patented a new heat pump design which incorporates heat storage into the design so that the system can use this rather than relying on a backup power source. This makes the system up to 10% more efficient than current designs.[62] It is these sorts of innovations engineers and designers in this industry must stay alert for and aware of.

"There's an excellent opportunity here. The Government's focus on heat pumps is only going to increase awareness of heat pumps and their benefits. This – along with the funding available to support consumers through the transition – will lead to more spend in the heat pump sector, greater opportunities for installers and the potential for the creation of many new jobs."

Darren Finley,
Managing Director of Commercial Products, Groupe Atlantic UK & ROI Division

[57] 'The heat pump installer gap', Nesta

[58] Ibid.

[59] 'Heat pumps: Lords slam 'failing' green heating scheme', BBC News

[60] 'Bristol City Council in £3m bid for heat pumps to cut emissions', BBC News

[61] 'Building the installer base for net zero heating', Heat Pump Association

[62] 'New heat pump designed to be more efficient and use less power', Homebuilding

The challenges

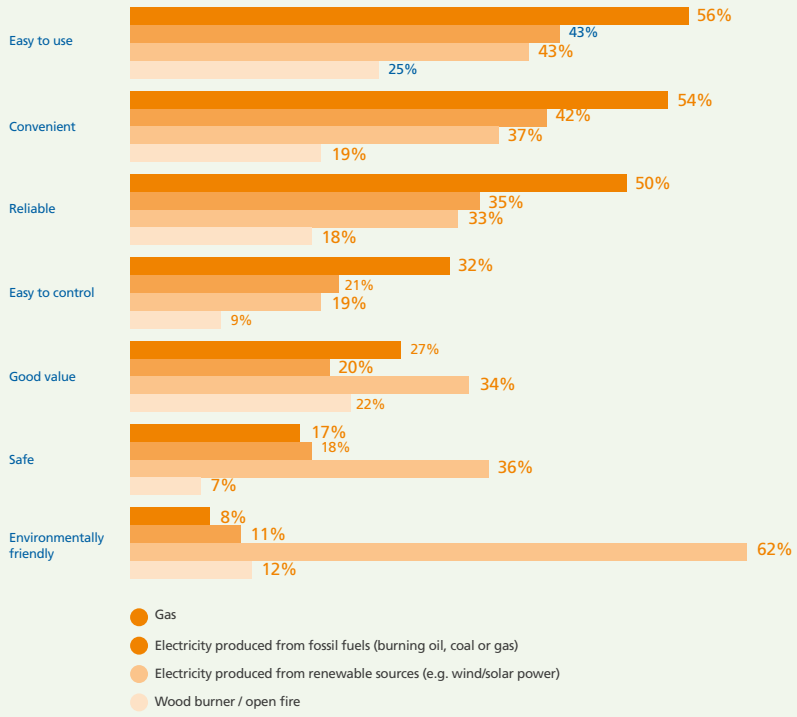
Implementing a roadmap to decarbonisation

Large scale changes are entirely necessary if the Government aims to achieve their goal of net zero, and the result won't be dependent on a single solution. Heat pumps and alternate renewable heating systems are only one step in the larger plan, but they are undoubtedly an important one, and this paper looks to support businesses starting to factor this into their own roadmaps.

A survey conducted by Nesta (a UK innovation foundation that provides programmes, investment, policy and research to promote innovation across a broad range of sectors) found that there is a huge value-action gap when it comes to renewable home technologies: while 85% of consumers agree that climate change is important, behaviours necessary to achieving net zero are not adopted fast enough nor at a large enough scale to meet the UK's climate goals.[63]

Perhaps one of the most challenging is the mindset transition required of the general public to change from the current gas boilers – which have been in use in the UK for decades – to heat pumps.

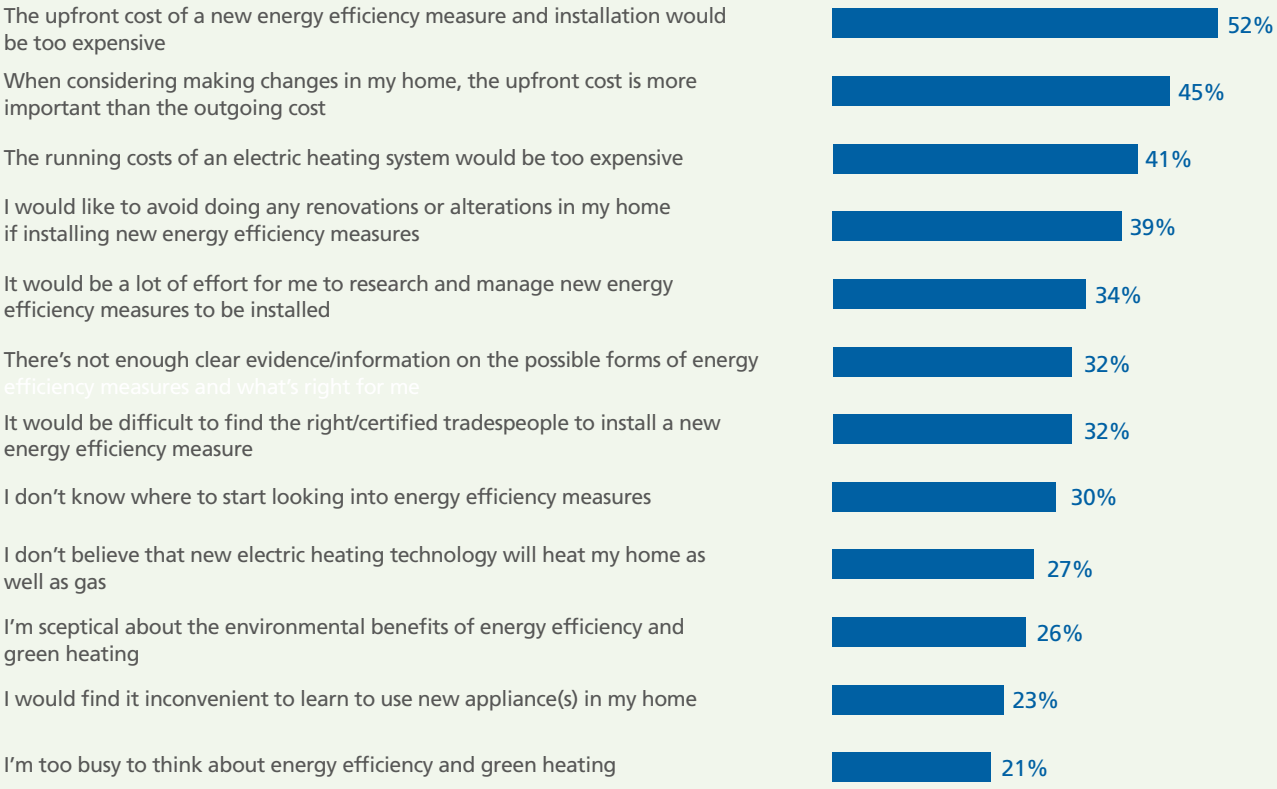
Associations of energy sources with different attributes



[63] 'Decarbonising homes: Consumer attitudes towards energy efficiency and green heating in the UK', Nesta

he apparent newness of the technology to consumers and commercial planners (the technology behind heat pumps has actually been around since before the gas boiler[64]), plus the current higher costs involved mean the plan could be met with some resistance. Overall, the majority of consumers are positive about the idea of having a renewable system in their home,[65] however, the reality of switching systems could be more difficult than some realise. Consumers have positive perceptions about gas, as they associate it with being easy-to-use (56%), convenient (54%) and reliable (50%).66 Consumers want comfort, affordability, safety and reliability from their heating,[68] whereas low carbon systems may be perceived as risking these factors. One way that this mindset could be tackled is through Nesta's proposed heat pump show home service – wherein potential heat pump consumers could observe heat pumps in action in a domestic setting.[69]

Barriers to adopting energy efficiency and green heating measures at home[67]



[64] 'History of heat pumps', Schweizerische Eidgenossenschaft

[65] 'Attitudes towards renewable heating, 2018', Statista

[66] 'Decarbonising homes: Consumer attitudes towards energy efficiency and green heating in the UK', Nesta

[67] Ibid.

[68] Joshua Bird – Lead Building Services Engineer, ARUP, CIBSE Build2Perform, December 2022

[69] 'Heat pump show home: Our running progress', Nesta

The challenges

Delays in replacing heating systems

People often delay replacing heating systems as long as possible, with many only replacing their gas boiler when it breaks (30%) or is about to break (31%)[70] and so need a fast replacement. This could cause issues when the system needs a complete revamp in order to install a heat pump instead of a new gas boiler. Beyond being a part of the Government's net zero strategy, addressing these perceptions will be essential in any roadmap plan to move from 'traditional' systems (such as gas boilers) to what are currently seen as more alternative heating systems – heat pumps.

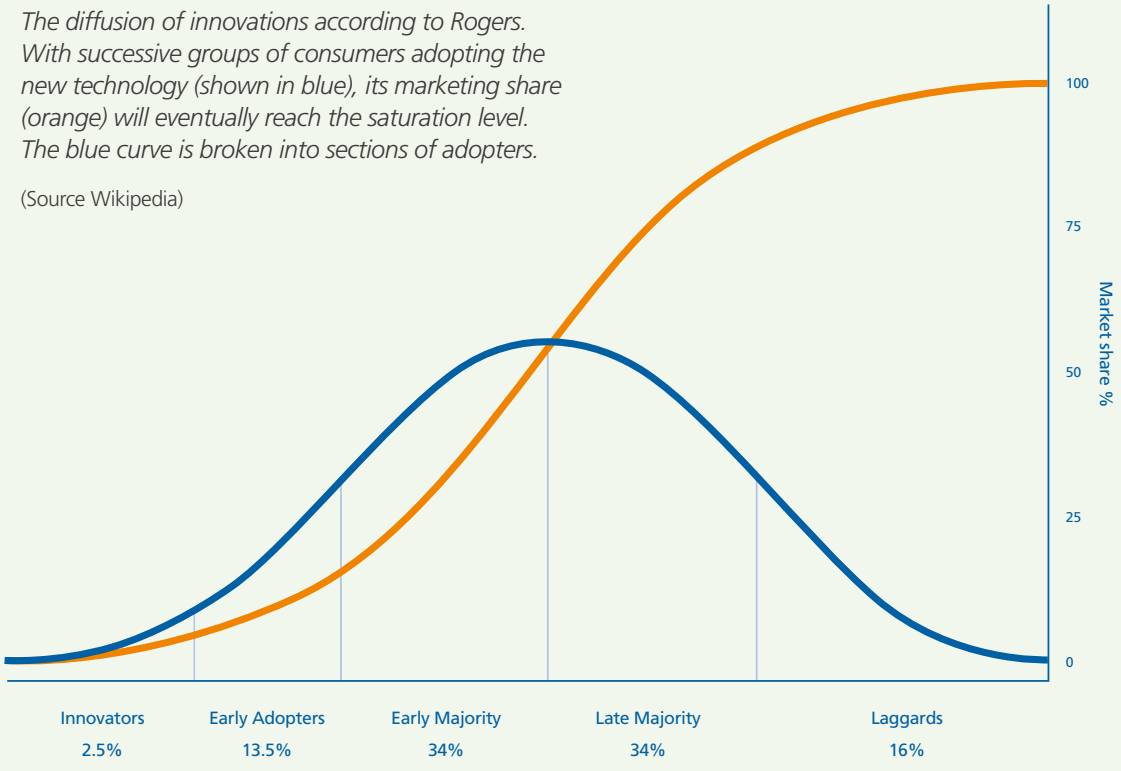
According to Nesta analysis, heat pump installations in the home are still in the innovator phase of the Rogers' model of the innovation adoption lifecycle.[71] Innovators are more likely to persevere through challenges, and will take risks in order to have the newest technologies and innovations that meet their needs and desires.[72] Early Adopters follow the Innovators, but do not take as many risks as Innovators and thus can be more difficult to convince.

With the planned increased adoption of heat pumps, as the Government has outlined, the industry – and workforce behind the industry – will have to strive to meet this target. As a result, information and upskilling of the workforce needs to remain consistent.

The high rate of adoption also comes with risks concerning consumer satisfaction. High demand and the skill gap could lead to poor installations which fail to work, resulting in widespread dissatisfaction amongst consumers and planners.

The diffusion of innovations according to Rogers. With successive groups of consumers adopting the new technology (shown in blue), its marketing share (orange) will eventually reach the saturation level. The blue curve is broken into sections of adopters.

(Source Wikipedia)



[70] 'Consumer challenges for low carbon heat', The ETI

[71] 'How understanding the user journey for heat pump adoption will generate innovation', Nesta

[72] Ibid.

As Andrew Johnson, Training Director for Groupe Atlantic, Groupe Atlantic UK, ROI & North America Division states:

"Tackling the skill gap now will be key to the future success of heat pumps in the marketplace – as the market scales up the need for installers will grow exponentially and we need to be prepared for that."

Tackling misinformation surrounding heat pumps – such as through increased training and thought leadership from industry experts – will also ensure that this strategy is rolled out safely, sensibly and with proper accreditation.

There are also complex socio-technical interactions (how people interact with the technology required to use heat pump systems) that massively impact heat pump performance and these need to be considered and taken into account in the design, installation and operation of heat pumps. Research has found that optimum system performance is impacted by the interaction of the monitoring system, the heat pump configuration, the occupants' heating practices and the heat load of the building (the amount of heating a building needs to maintain the indoor temperature at established levels73).74

Plus, when it comes to retrofitting heat pumps, there is the additional challenge of having to deal with two heating infrastructures (gas boiler and heat pump) during the transition. It is likely that new radiators and a new hot water tank will also be required, and other elements of the system will need replacing to work with the heat pump; all of these can be costly, in both time and money,75 and deter potential consumers and commercial planners from making the switch until they absolutely need to.

On top of this, there are some potentially more intricate challenges facing heat pumps as the phase-down of hydrofluorocarbons (HFCs) begins. The Montreal Protocol (the global agreement made to protect the stratospheric ozone layer through the phasing out of production/use of ozone depleting substances76) meant that there was a phase-down of hydrochlorofluorocarbon gases resulting in heat pumps, refrigeration and air conditioning industries made a move towards HFC refrigerants. However, under the Kigali Amendment, made in 2016, HFC refrigerants will also need to be reduced by 85% by 2036. Innovation will be key in selecting the best refrigerant alternatives for heat pumps going forward.

[73] 'Understanding heat load and heating capacity', Save Home Heat Co

[74] 'Ecology of heat pump performance: A socio-technical analysis', SpringerLink

[75] 'Can you retrofit air source heat pumps?', Source Heat Pump

[76] 'The Montreal Protocol on substances that deplete the Ozone layer', U.S. Department of State

The challenges

Delays in replacing heating systems

Alongside these complex technical issues, there is also the cost of space required for heat pumps. Space is at a premium from small apartments up to large commercial properties, which consumers and planners will be reluctant to sacrifice.

Between 2008 and 2021, the total installed wind capacity for the UK increased by 23.7 gigawatts to a total of 27.1 gigawatts.[77]

The UK also needs to see the decoupling of gas and electricity prices. The price of electricity is still driven and dictated by gas even if there's a lot of wind on the grid.

Andrew Sissons, deputy director of the sustainable future programme at Nesta, argues that innovations around the costs of electricity prices needs to occur at a government level:

"In general, in Europe, the countries which have the lowest ratio of electricity to gas prices are the countries that generally have the highest heat pump uptake rates […] The cheaper your electricity is, relative to gas, the cheaper a heat pump is to run relative to a gas boiler." [78]

Additionally, researchers agree that while heat pumps are key in achieving net zero, if we are to rely wholly on them then "we must invest in our electricity network and become more flexible in how we use energy to keep the lights (and the heating) on."[79] Of course the question then becomes how can we invest in our energy? The Government is taking steps to become more flexible in the nation's energy use. For example, the Government established UK Industrial Fusion Solutions Ltd to deliver a prototype fusion energy plant in Nottinghamshire. This plant is due to complete construction by 2040. Fusion energy could be key to the future of decarbonising as it is a 'near limitless, low carbon energy source'.[80] The type of fusion this plant will focus on is magnetic confinement fusion, which occurs when a mix of two forms of hydrogen are heated to extreme temperatures (10x hotter than the core of the sun) and fuse together to create helium and release huge amounts of energy.

Energy created from fusion can be used to generate electricity in the same way as existing fossil fuel power stations, but it's "many million times"[81]more efficient, and the raw materials needed to provide fuel for the process are readily available in nature. A number of significant technical

[77] 'UK: Installed wind power capacity, 2021', Statista

[78] 'UK consumers hesitate to install heat pumps', Financial Times

[79] 'Heat pumps: UK to install 600,000 a year by 2028 but electrical grid will need massive investment to cope', The Conversation

[80] 'UK takes major STEP towards near limitless, low-carbon energy', GOV.UK

hurdles remain, but the Government's STEP (Spherical Tokamak for Energy Production[82]) programme is set up to address these and pave the way for commercialisation of fusion in the future.[83]

This past year above all has indicated the truly volatile nature of energy prices, with supply chain issues following the pandemic and the conflict in Ukraine limiting supplies of natural gas and causing prices to surge. The UK currently imports about 50% of its gas[84] and gas also fuels around a third of the UK's electricity generation, so electricity prices have risen alongside gas prices.[85] These unsteady gas and electric prices are also accompanied by the fact that the UK is on the edge of a recession[86] and all of these factors require attention and management alongside the Government's net zero target.

There are also specific challenges for manufacturers, such as supply chain issues still affecting stock[87] and issues with upskilling the manufacturing workforce to handle the new elements required for heat pumps.[88] Plus, as Darren Finley, Managing Director of Commercial Products for Groupe Atlantic UK & ROI Division, states,

Ultimately, while this is a necessary shift that the UK needs to make, it also needs to be carefully considered, planned, and outlined, in order to negate as many of these risks and challenges as possible.

[81] Ibid.

[82] 'UK to take a big 'STEP' to fusion electricity', GOV.UK

[83] 'UK takes major STEP towards near limitless, low-carbon energy', GOV.UK

[84] 'Chapter 4: Natural Gas by Addy Mettrick and Damon Ying', GOV.UK

[85] 'The energy price crunch', House of Commons Library

[86] 'What is a recession and how could it affect me?', BBC News

[87] 'Made in the UK: Challenges facing heat pump installers', Renewable Heating Hub

[88] 'Heat pump manufacturing supply chain research project report', GOV.UK

Strategic implementation to optimise heating resources

Changes made to Building Regulations Part L in 2021 took effect on 15th June 2022, with a deadline for planned implementation of 15th June 2023. These changes, centred around the Seasonal Efficiency of both domestic and non-domestic buildings, are intended to ensure that new and replacement equipment is efficient and in line with the Government's carbon reduction goals. For example, in commercial buildings, like-for-like on-site replacements of non-condensing water heaters will not be allowed, barring certain exceptional circumstances. While previously building regulations have had certain flexibilities, these new changes have been made much more stringent to ensure that both new and existing buildings are ready for low carbon heating. From June of this year, all new buildings must align with the changes to regulations.

The clue here is in the terminology – roadmap, journey, plan. There isn't a one-stop, overnight solution to get to net zero and decarbonise UK heating; this is going to be a stepped process.

It's clear that there are challenges here, but also plenty of opportunities. Key to this transition is taking those opportunities and moving forward with the momentum of this net zero journey.

"It's essential that this is a stepped process – I don't think we can overstate the importance of that. We need to bring stakeholders along on the journey towards low carbon technology products – guiding them through the process and educating them of the benefits of each step – helping them understand how to make the right steps at the appropriate time."

Chris Caton,
Product Director, Groupe Atlantic UK, ROI & North America Division

[89] 'Types of glazing for your windows, explained – a complete guide', Ideal Home

1. Review building fabrics

A perfect heating system is still dependent on its building's heat retention abilities; if the building leaks a lot of heat, energy is still being wasted, no matter how well the heating system performs. So a part of both new and retrofit installations of renewable heating resources is looking at how well insulated the house is: optimising window glazing; ensuring reliable insulation and effective radiators.

Window glazing, insulation and radiators are a key part of ensuring that any heating system is properly supported. Up to 24% of heat energy can escape through old, inefficient glazing,[89] so it is important that double- or triple-glazing is utilised in properties where they can be, with the few exceptions of listed buildings where traditional single-pane windows must be kept.

Even more heat energy is lost through poor insulation, in both the walls and loft of a home. In fact, poor wall insulation accounts for 35-40% of heat loss[90] and around 25% of heat can be lost through the roof in an uninsulated home.[91] There is a great variety of insulation options, a wide range of choices depending on the structure and build of each home. Radiators mounted on an external wall will lose a lot of heat through that wall, therefore some recommend radiator reflectors which bounce back 95% of energy that would otherwise be lost through the wall.[92]

2. Optimise existing heating systems

As mentioned, there is a risk with this increasing rate of adoption of heat pumps: that of poor installations and a resulting widespread consumer dissatisfaction.
A second phase to implement, which could aid in preventing part of this dissatisfaction, is the optimisation of existing systems. Combining new technology with the old, to help gas boilers operate more efficiently, and make the transition from one to the other smoother.

The average boiler in the UK now runs for between 10-15 years,[93] meaning many of those who are replacing their gas boilers now will not need to switch their heating source for at least a decade – unless they personally make the choice to switch early. By encouraging consumers to optimise their current systems, they can help their gas boilers operate more efficiently. For example, informing consumers that they should be lowering the flow temperature of the boiler, and not the thermostat, in order to lower their emissions. Most boilers should be set to a flow temperature of 60°C or lower to increase the chance of them running at the optimum 95% optimum condensing efficiency – but most current boilers are installed to have a flow temperature of 70-80°C. Optimising boilers can reduce household gas use, costs, and emissions by 6-8%.[94]

3. Introduce low carbon technologies

It is absolutely crucial to implement this step at a strategic point. Heat pumps are a well-established low carbon technology, but the innovation that comes with the market scaling-up means an ever-increasing range of applications.
This brings with it a number of questions that engineers and designers must consider: what are these innovations? What are manufacturers doing?

It is the duty of engineers and designers to stay on top of the latest innovations.

For example, the University of Salford's experimental house "The Future Home" is testing an air-source heat pump within the loft space which could help solve issues of space and aesthetics consumers may be concerned with.[95]

[90] '7 ways heat loss in a house happens – and costs you money!', Homebuilding & Renovating

[91] 'Roof and loft insulation guide', Energy Savings Trust

[92] 'Best radiator reflector 2023: The simple way to make your radiators more effective', Expert Reviews

[93] 'How long do boilers last', HomeServe

[94] 'Lowering boiler flow temperature to reduce emissions', Nesta

[95] 'Heat pumps on UK roofs!', Energy Live News

Strategic implementation to optimise heating resources

It is also important to stay up to date with the latest developing industry best practices, such as guidance outlined by the Chartered Institution of Building Services Engineers (CIBSE) and the Building Engineering Services Association (BESA). Both organisations are regularly updating their recommendations and guidelines following new research into this rapidly changing technology. These are often summarised in publications such as CIBSE's AM17, which, released in 2022, consolidates best practice guidance for heat pumps intended for large non-domestic buildings in order to support their high-quality design, installation, commissioning, operation and maintenance. For example, CIBSE summarise the changes to Part L of the Building Regulations for England and Wales discussed earlier in this paper.[96]

The Government's banning of gas boilers in domestic new builds from 2025 means that many of these developing properties are prime for the installation of low carbon heating systems. However, we know that the largest market for heat pumps is in retrofit – and retrofits will need to be included if the Government is to achieve their goal of 600,000 new installations a year – so alternatives may need to be considered. Hybrid systems which combine heat pumps and gas boilers may aid in bridging the gap for those buildings which are not ready to rely completely on low carbon technology.

These hybrid systems, also known as bivalent systems, combine a heat pump with an additional or existing heat source – often a gas boiler.[97] This amalgamation of traditional heating sources with more novel low or zero carbon technologies is a well-established method of reducing the carbon impact of heat generators.[98] In fact, such hybrid systems could reduce the usage of gas by up to 70.99 The best of these bivalent systems will maximise the contribution of the heat pump to the total load.[100]

Interest in hybrid systems is growing steadily, both from a consumer point of view as well as within the UK Government, further cementing them as a prospective pathway for future innovation.

The complexities of working these things out only serves to highlight how heat pumps are not a 'one size fits all' solution. Good engineering practice and education is required.

Heat pumps can fit almost anywhere: retrofit or new build, domestic or industrial and commercial, mixed-use developments (supermarket / housing area). But with that comes the logistics of installation – the challenges we discussed above: space cost, fitting with existing systems etc. Not only that, but plans must be made holistically, making provisions for how the technology might evolve and considering the Coefficient of Performance (COP) at all times. How can we reduce flow temperature further?

Another important question to consider when introducing this low carbon technology is: which buildings are heat pump ready now and which will be ready in the future?

"Heat pumps are the future. There can be no doubt about that. The Government has made this clear in their net zero strategy, and we need to be strategically planning for their implementation. We're currently at a tipping point in the market – with rising energy prices, price parity between gas and electricity and the ongoing innovation in the sector – there's a real opportunity here. Now is the time to start planning your decarbonisation strategy and join the net zero journey."

Darren Finley,
Managing Director of Commercial Products, Groupe Atlantic UK & ROI Division

[96] 'AM17 Heat pump installations for large non-domestic buildings', CIBSE

[97] 'What is the difference between a Monovalent system and a Bivalent system?', Grant UK

[98] 'Module 205: Bivalent heat pump systems for heating and hot water', CIBSE Journal

[99] 'Hybrid heat pumps: Are they right for your home?', Homebuilding & Renovating

[100] 'Module 205: Bivalent heat pump systems for heating and hot water', CIBSE Journal

Implementing the roadmap to decarbonisation

When implementing low carbon heating options, make sure you choose the right partner to help.

With over 100 years' experience, Hamworthy Heating provides commercial energy professionals with the best possible support and knowledge in commercial heating and hot water projects. This specialist knowledge is built up from decades of experience in researching, designing and building market leading products in the UK.

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Look out for our next white papers that will delve into the skills gap, HIUs and hybrid systems.

"The world of commercial heating is changing, and we want to be at the forefront of it. As well as bringing heat pumps and hydrogen products to market, we'll be there to support in the application of new low carbon technologies, to ensure they deliver on comfort, cost and sustainability."

Chris Caton, Product Director,
Groupe Atlantic UK, ROI & North America Division

Heating must be: comfortable; affordable; reliable; low carbon; safe; future-proofed.

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